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The Proceedings for the past year of the American Association for the Advancement of Science have been distributed to the members; they do honor to the Society by whom they are issued, and hold forth the brightest hopes for its future.

The friends of the Association will learn with satisfaction that the number of members steadily increase, and that the roll of honor now comprises one thousand five hundred and fifty-five names, a glance at the list showing that it represents the intelligence of the United States.

The very laudable objects of the Association are the advancement of Science, which it endeavors to carry into effect by arranging annual meetings of its members, "to promote intercourse between those who are cultivating Science in different parts of America, its Constitution expressing the desire to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness."

It will thus be seen that the leading feature of the Association is *co-operation*, the secret of all success and the keystone of human progress. Perhaps in no country in the world does this necessity for co-operation exist to a greater degree than in the United States, with its vast amount of territory and great area.

Men of education, with minds specially adapted for the highest scientific work, are often isolated from their fellow workers, and thousands who are "cultivating" Science are spread over the States and Territories, silently plodding over problems of vital interest or investigating the great scheme of Creation. Surely an Association which is a bond of union between such a widely dispersed class should be recognized on its merits by those for whose benefit it is established, and we may add, that the only practical sign of appreciation of the advantages offered, is active membership.

The Association at present numbers fifteen hundred members, and has an income of less than six thousand dollars, a sum which is well husbanded and turned to the best advantage by the executive officers of the Association, who are enabled this year to present two handsome volumes to each member, which are alone equivalent in value to the subscription paid.

We desire, however, to see the list of members largely increased, and considering the Association has existed over thirty years, the number should not be less than five thousand, an income would then be at the disposal of the Executive Committee which would enable it to encourage scientific research in a manner worthy of the Association and the cause of human progress which it represents.

We desire also to see the permanent fund of the Association placed on a more substantial footing, and supported by those who can strengthen it from their superabundant wealth, without a financial effort on their part.

We speak within bounds when we assert, that it is a standing scandal and reproach on the *men* of intelligence of the United States, to find that the *single patron* of the "American Association for the Advancement of Science" is a *woman*. Is there no American gentlemen with sufficient chivalry to follow so bright an example? We trust that the meeting of the Association, which will open next week, will not close without at least one response, to the challenge we now make.

ASTRONOMICAL OBSERVATORIES.

By Simon Newcomb.

Among the contributions of public and private munificence to the advance of knowledge, none are more worthy of praise than those which have been devoted to astronomy. Among all the sciences, this is the one which is most completely dependent upon such contributions, because it has the least immediate application to the welfare of the individual. Happily, it is also the science of which the results are best adapted to strike the mind, and it has thus kept a position in public estimation which it could hardly have gained if it had depended for success solely upon its application to the practical problems of life. That the means which have been devoted to its prosecution have not always been expended in a manner which we now see would have been the best, is to be expected from the very nature of the case. Indeed, a large portion of the labor spent in any kind of scientific research is, in a certain sense, wasted, because the very knowledge which shows us how we might have done better has been gained through a long series of fruitless trials. But it is due both to ourselves and the patrons of astronomy that as soon as any knowledge bearing upon the question of

the past application of money to the advance of science is obtained, use should be made of it to point out the mistakes of the past and the lessons for the future. It is now patent to all who have made a wide study of the subject that large amounts have been either wasted or applied in ways not the most effective in the erection and outfit of astronomical observatories. Since Tycho Brahe built his great establishment at Uraniburg, astronomical research has been associated in the public mind with lofty observatories and great telescopes. Whenever a monarch has desired to associate his name with science, he has designed an observatory proportional to the magnitude of his ambition, fitted it out with instruments on a corresponding scale, and then rested in serene satisfaction. If we measure greatness by cubic yards, then Peter the Great and "Le Grand Monarque" were the founders of two of the greatest observatories ever built. That of St. Petersburg was completed in 1725, the year of Peter's death, and was an edifice of two hundred and twenty-five feet front, with central towers one hundred and forty feet high. It had three tiers of galleries on the outside for observation, and was supplied with nearly every instrument known to the astronomers of the time, without reference to the practicability of finding observers to use them. It was nearly destroyed by fire in 1747, but was partially rebuilt, and now forms part of the building occupied by the Imperial Academy of Sciences. The Paris Observatory, built half a century earlier, still stands, its massive walls and arched ceilings reminding one rather of a fortress than of an astronomical institution.

Notwithstanding the magnificence of these structures, they have had little essential connection with the progress of astronomy. It is true that the work done at both establishments takes a prominent place in the history of science, but most of it could have been done equally well under wooden sheds erected for the protection of the instruments from the weather. In recent times, the St. Petersburg Observatory has been found so unsuitable for its purpose that no observation of real value can be made, and its existence has been nearly forgotten. The great building at Paris, though associated with a series of astronomical researches second to none in the world, has really served scarcely any other purpose than those of a physical laboratory, store-house and offices. The more important observations have always been made in the surrounding garden, or in inexpensive wings or other structures erected for the purpose.

With these establishments it will be instructive to compare the Greenwich Observatory. The latter has never won the title of great. It was originally established on the most modest scale, for the special purpose of making such observations as would conduce to the determination of the longitude at sea. Although it has now entered upon its third century, no attempt has ever been made to reconstruct it on a grand scale. Whenever any part of it was found insufficient for its purpose, new rooms were built for the special object in view, and thus it has been growing from the beginning by a process as natural and simple as that of the growth of a tree. Even now, the money value of its structure is less than that of several other public observatories, although it eclipses them all in the results of its work. Haeckel lays it down as a general law of research that the amount of original investigation actually prosecuted by a scientific institution is inversely proportional to its magnitude. Although this may be regarded as a humorous exaggeration, it teaches what the history of science shows to be a valuable lesson.

A glance at the number and work of the astronomical observatories of the present time will show how great a waste of means has been suffered in their erection and management. The last volume of the "American Ephemeris" contains a list of nearly 150 observatories, supposed to be, or to have recently been, in a state of "astronomical activity." The number omitted because they have lain inactive it is impossible to estimate; but it is not unlikely that, in this country at least, they are as numerous as those retained. It is safe to say that nearly everything of considerable value which has been done by all these establishments could have been better done by two or three well-organized observatories in each of the principal civilized countries. Indeed, if we leave out of account local benefits, such as the distribution of time, the instruction of students, and the entertainment of the public, it will be found that nearly all the astronomical researches of really permanent value have been made at a very small number of these institutions. The most useful branch of astronomy has hitherto been that which, treating of the positions and motions of the heavenly bodies, is practically applied to the determination of geographical positions on land and at sea. The Greenwich Observatory has, during the past century, been so far the largest contributor in this direction as to give rise to the remark that, if this branch of astronomy were entirely lost, it could be reconstructed from the Greenwich observations alone. During the past twenty years, the four observatories at Greenwich, Pulkowa, Paris and Washington have been so far the largest contributors to what we may call geometrical astronomy that, in this particular direction, the work of the hundred others, in the northern hemisphere at least, can be regarded only as subsidiary.

This remark, it will be understood, applies only to that special branch of astronomy which treats of the positions and motions of the heavenly bodies. The other great branch of the science treats of the aspect and physical constitution of these bodies. It dates from the invention of the telescope, because, without this instrument and its accessories, no detailed study of the heavenly bodies is possible. The field open to the telescope has, during the last twenty years, been immensely widened by the introduction of the spectroscope, the ultimate results of which it is scarcely possible to appreciate. Photography has recently been introduced as an accessory to both instruments; but this is not so much an independent instrument of research as a means of recording the results of the spectroscope and telescope. To this branch of the science a great number of observatories, public and private, have duly contributed, but, as we shall presently see, the ratio of results to means is far less than it would have been had their work all been done on a well-organized system.

Nearly all great public observatories have hitherto been constructed for the purpose of pursuing the first branch of the science,—that which concerns itself, so to speak, with the geometry of the heavens. This was naturally the practice before the spectroscope opened up so new and rich a field. Even now, there is one sound reason for adhering to this practice—namely, that physical investigations, however made, must be the work of individuals, rather than of establishments. There is no need of a great and expensive institution for the prosecution of spectroscopic observations. The man of genius with imperfect instruments will outdo the man of routine in the greatest building, with the most perfect appliances that wealth can supply. The combination of qualities which insures success in such endeavors is so rare that it is never safe to count upon securing it. Hence, even now, a great observatory for the prosecution of physical research would be a somewhat hazardous experiment, unless the work it was to do were well mapped out beforehand.

Considering the great mass of observatories devoted to geometrical astronomy, the first thing to strike the professional student of their work is their want of means for a really useful and long-continued activity; and this notwithstanding that their instrumental equipment may be all that could be required. The reason is that their founders have not sufficiently taken into account the fact that the support of astronomers and the publication of observations is necessary to the usefulness of such an

establishment, and requires a much larger endowment than the mere outfit of the building. Let us take, for instance, that omnipresent and most useful instrument, the meridian circle. Four or five of these instruments, of moderate size, located in good climates, properly manned, under skillful superintendence, working in co-operation with each other, would do everything necessary for the department of research to which they are applicable, and a great deal more than is to be expected from all the meridian circles of the world, under the conditions in which they are actually placed. They could, within the first five years, make several independent determinations of the fundamental data of astronomy, including the positions and motions of several hundred of the brighter fixed stars. In five years more, they could extend their activity so as to fix the position of every star in the heavens visible to the naked eye; and, during the ten years following, could prepare such a catalogue of telescopic stars as there is no prospect of our seeing during the next half-century.

There are probably not less than twenty meridian circles in this country alone, most of them antiquated, it is true, yet, so far as average size and cost are concerned, amply sufficient for the work in question. How many there may be in other countries it is impossible to estimate, but probably fifty or upward, and the number is everywhere constantly increasing. Should we seek out what they are doing, we should probably find half of them rusting in idleness upon their pivots. With others, some industrious professor or student would be found making, unaided, a series of observations to be left among the records of the establishment, or immured in the pages of the "Astronomische Nachrichten," with small chance in either case of ever being used. We may be sure that the solitary observer will soon find something else to do, and leave the instrument once more in idleness. Others we should find employed in the occasional instruction of students, a costly instrument being used where a rough and cheap one, which the student could take to pieces and investigate at pleasure, would answer a far better purpose. Yet others we should find used in distributing time to the neighboring cities or states, or regulating chronometers for the shipping of a port. I dare not guess how many we should find engaged in work really requiring an instrument of the finest class, and gaining results which are to contribute to the astronomy of the future, but in our own country there would hardly be more than three.

The general cause of this state of things lies upon the surface. It is as true in astronomy as in any other department of human affairs that the best results can be attained only by a careful adaptation of means to ends. Failures have arisen, not from the intervention of any active opposing agency, but because observatories have been founded without a clear conception of the object to be attained, and therefore without the best adaptation of means to ends. To build an observatory before knowing what it is going to do is much like designing a machine shop and putting in a large collection of improved tools and machinery before concluding what the shop is to make, and what are the conditions of the market open to its products. Some hints on the considerations which should come into play in the erection of any new observatory may not be out of place, as pointing out the remedy for the evils we have described.

Heretofore, the practice has usually been first to decide upon the observatory, and to plan the building; next, to provide instruments; and lastly to select an astronomer, and, with his advice, to decide what direction the activities of the establishment should take. This order of proceeding should be reversed. The first thing to be done is to decide what the observatory shall be built to do. The future astronomer would, of course, have a controlling voice in this decision, and should, therefore, be selected in advance. One thing which it is especially important to decide is to which of the two great divisions of astronomical research attention shall principally be directed. If the prosecution of geometrical astronomy is kept in view, the conditions of advance in that department of the science must be kept in mind. The public is too apt to associate astronomy with looking through a telescope. That some of the greatest astronomers of modern times, such as Kepler, Newton, Hansen, Laplace and Leverrier, scarcely ever looked through a telescope as astronomers, is not generally understood. For two thousand years, astronomy has furnished the great geometers of the world with many of their profoundest problems, and thus has advanced hand in hand with mathematics. It borrows its fundamental data from observation, but the elaboration and development of its results taxes the powers of the mathematical investigator. The work of making the necessary observations is so much easier than that of developing the mathematical theories to which they give rise, that the latter is comparatively neglected alongside the former. It is lamentable to see what a collection of unused observations are found in the pages of scientific periodicals, to say nothing of those which have remained unpublished in the records of observatories. Under these circumstances, it is not worth while to found any more observatories for the prosecution of geometrical astronomy, except under special conditions. Among these conditions we may enumerate the following:

First. The institution should have such an endowment as to secure the continuous services of two or three observers, and to publish at least the results of their observations in a condensed form.

Second. The instrument should be of the finest class, but not necessarily of large size. This is not a difficult condition to fulfill, since such instruments are not very costly. One reason for observing it is that it is only within the last few years that the highest perfection has been attained in the construction of instruments of measurement.

If these two conditions can be really fulfilled, it is very desirable to add a few more to the great number of meridian circles now in existence, for the simple reason that it is easy to exceed them in perfection. It is, however, to be remarked that a good climate is a scientific prerequisite for the success of an observatory of any kind. The value of observations is decidedly lessened by the breaks in their continuity due to the intervention of clouds. It is therefore extremely desirable that, so far as possible, new observatories should hereafter be erected under sunny skies.

If an observatory is to be devoted to physical research, a more modest outfit, both in the way of endowment and of instrumental means, may be sufficient to serve an excellent purpose. Instead of being a great co-operative work, requiring the continuous labor of several persons, physical research may be divided up into sections almost as small as we please, each of which may be worked by an individual astronomer with any instrument suited to the purpose in view. To the success of such an observatory, a clear sky is even more necessary than to one engaged in measurement. Whether a great telescope will be necessary, will depend principally upon what is to be done. The consideration which is really of the first importance is the astronomer. The man who is really wanted will do more with the most inexpensive instruments than another one with the most costly ones. As already remarked, physical research is mainly the work of the individual, and what we want is to secure the services of the ablest man and then supply him with such means of research as are necessary to the problems he has in view. New questions are arising so frequently, and the field of physical research is now so wide, that it is impossible to lay down any general rules for a physical observatory, except that means should be furnished for supplying the investigator with any instrument he may want.

A third class of observatories are those intended for instruction in astronomy. The requirements in this direction are so different from those necessary to research that it is impossible to combine the highest efficiency in both directions with the use of the same instruments. The number of observatories especially designed for pure instruction are very few in number. The instruments necessary for the purpose are of the simplest kind; indeed, so far as mere training is concerned, the engineer's level, transit, and theodolite can be made to serve most of the purposes of the astronomical student. What the latter really wants is that training of the eye and the mind which will enable him to understand the theories of instruments, the methods of eliminating the errors to which they are subject, and the mathematical principles involved in their application. In this, as in nearly every department of professional education, we may lay it down as a rule that the wants of a liberal and of a professional education are, so far as the foundation is concerned, identical. We are too prone to lead the student into the minute details of a subject without that previous training in first broad principles which, though it may not immediately tell on his progress as a student, will be felt throughout his life to whatever field of work he may devote himself. Such a transit instrument as Hipparchus might have made,—a wooden level mounted on an axis and supplied with slits to serve the purpose of sights,—properly mounted in the meridian, could well be made to take the place of the transit instrument for purposes of instruction. Scarcely any higher skill than that of a cabinet-maker would be required in its construction. The object at which the student should then aim would be, with the aid of this instrument, to determine the error of his clock or watch within a few seconds. If he is really acquainted with the principles of the subject, and has his eyes properly trained, he will have no difficulty in soon learning to do this.—(*North American Review*).

MICHIGAN FLORA.

By CHARLES F. WHEELER and ERWIN F. SMITH, Hubbardston, Michigan.

The following interesting sketch forms the preface to a catalogue of the Phænogamous and vascular Cryptogamous Plants of Michigan, Indigenous, Naturalized and Adventive, which can be obtained of W. S. George & Co., of Lansing, Michigan:

The climate of the Upper Peninsula of Michigan is colder than that of the Lower Peninsula, the surface is considerably broken, especially in the western part, and the flora is in many respects decidedly northern, resembling in part that of British America, and in other respects like that of N. New England and Canada. Pines, firs, cedar, larch, junipers, elms, poplars, black ash, basswood, maples, and birches, are the principal trees. *Pinus strobus*, the prevailing species southward, is here largely supplanted by its more northern and less valuable congener, *P. resinosa*, whose tall, slim trunks are, however, in good demand for driving piles. Under-shrubs, like *Rubus Nutkanus* and *Taxus baccata*, var. *Canadensis*, are common, and indicate a tendency toward northern types that we find more strongly developed in the herbaceous plants. Among the latter we note as found rarely, or not at all, in the Lower Peninsula, but frequently northward, and often having a high northern range, such plants as *Anemone parviflora, Viola Selkirkii, Potentilla frigida, Stellaria borealis, Saxifraga Aizoon, S. tricuspidata, Pinguicula vulgaris, Castillea pallida, Halenia deflexa, Physalis grandiflora, Tofieldia, palustris, Salix adenophylla, Eriophorum alpinum, Aspidium fragrans*, etc., etc.

The influence of climate on vegetation may be summed up in a few words. The climate of the Lower Peninsula is not as severe of as that of the Upper, nor so even, but is subject to frequent, sudden, and extreme changes of temperature—as great a variation during the winter season as 53° Fahr. in less than 24 hours having been recorded. Such rapid changes more or less affect vegetation, especially the tender branches of cultivated trees, which are sometimes seriously injured. In one or two instances a like effect on our forest trees has been noticed. The annual range of temperature is about 116°, and the annual mean 46°. Of rain-fall, including what falls in form of snow, we have, yearly, about thirty inches. Our snow-fall is much less, for the same latitude, than that of New York and New England. In the center of the peninsula, we seldom have more than a few inches at a time.

The proximity of the Great Lakes exerts a marked influence in equalizing the temperature and the effects are marked upon our flora.

Trees like *Liriodendron Tulipifera, Asimina triloba, Cercis Canadensis, Gleditschia triacanthos, Cornus florida, Nyssa multiflora* and *Morus rubra*, which belong to Ohio and Central Illinois, have crept northward, favored by the mild influence of the lake winds, through the central and western part of the Lower Peninsula, often beyond the middle, and the same is true of smaller and less noticeable plants.

As might be expected from the uniform surface of the peninsula, the flora is much alike throughout. Probably three-fourths of our species are common to all sections, though by no means equally distributed; some being very abundant in one district and rare in another at no great distance. In most cases such change is due to soil rather than to difference in elevation, temperature, or atmospheric moisture.

The Lower Peninsula is covered with a deep drift of alternating sands, clays and gravels, and the flora of any section depends chiefly on which of these happens to lie uppermost. With reference to its flora, the Peninsula may be roughly divided into two great divisions—the hard-wood and the soft-wood lands; one representing the Appalachian flora, and the other, the Canadian.

The hardwood country lies south of latitude 43°, and consists of very fertile sand, clay, or loam, mostly cleared of the original forest, and largely cultivated.

The sandy or stony drift of many river valleys in this section supports a heavy growth of oak, frequently interspersed with walnut and hickory, while the margins of the streams, and the neighboring swamps, abound in soft maples, swamp and chestnut oak, white and black ash, elm, hackberry, sycamore, butternut and similar trees. Willows, dogwoods, viburnums, and buttonbush, are common shrubs in the swamps; and hazel, hawthorn, wild cherry and plum, June berry, witch-hazel, etc., are abundant on the dryer ground.

On the uplands, and away from streams, clay, loam, and a peculiar blackmuck soil, supersede the sands and gravels of the valley. The prevailing timber here is beech and maple and oak forest in about equal proportions. Beech and maple (*Acer saccharinum* and var. *nigrum*) generally grow together, forming magnificent forests of great extent. The best wheat farms are usually found on uplands near streams, where the oak timber gradually shades into beech and maple. Plains of fertile sand covered with a low, or scattering growth of oak (oak openings) are frequent, and always very desirable for farming purposes. Four species of oak are usually found on such plains—*Q. alba, macrocarpa, coccinea* and *tinctoria*.

Marshes densely covered with tamarack are common in this part of the State, and nourish in their thick shade such plants as *Drosera rotundifolia, Sarracenia purpurea, Rhus venenata, Ribes rubrum, Chiogenes hispidula, Salix candida, Smilacina trifolia, Pogonia ophioglossoides* and *Calopogon pulchellum*. Arborvitæ, red cedar and black spruce are comparatively rare.

A similar tract of soil and timber occurs in the upper end of the Peninsula, north of a line drawn from Thunder Bay west to the head of Grand Traverse Bay. This is commonly known as the "Traverse Region," and has a flora much like that we have just described, with the exception that some of the southern species disappear, and northern ones begin to take their place, or if found growing further south, here first become frequent.

The littoral flora of Little Traverse Bay is rich in interesting species, among which may be mentioned a small form of *Cakile Americana, Lathyrus maritimus, Potentilla Anserina, Tanacetum Huronense, Artemisia Canadensis, Cnicus Pitcheri, Juncus Balticus, Triticum violaceum, T. dasycarpum*, a peculiar form of *Bromus ciliatus, Calamagrostis longifolia, C. arenaria, and Equisetum variegatum.* The flora of the low dunes at the head of the Bay comprises, among others, the following species: *Juniperus Sabina*, var. *procumbens, Prunus pumila* and *Cornus stolonifera*, half buried in the drifting sand, *Hypericum Kalmianum, Salix glaucophylla*, and varieties, *Lilium Philadelphicum*, etc. In a moist depression were found *Arabis lyrata, Coreopsis lanceolata, Arctostaphylos Uva-ursi, Primula farinosa, Lithospermum hirtum, Triglochin maritimum*, var. *elatum, Carex aurea, C. Œderi*, etc., etc. In thickets near the shore were found *Abies balsamea, Picea alba, Sheperdia Canadensis, and Rubus Nutkanus.* Deep forests of hemlock and yellow birch (*B. lutea*) mixed with a fine, tall growth of striped maple (*A. Pennsylvanicum*) are frequent, having underneath a tangled growth of *Taxus baccata*, var. *Canadensis*, and under all a carpet of *Lycopodium annotinum.* Alternating with these are sandy plains covered with a dense growth of *Vacciniums*, yielding a great abundance of fruit. Sugar maples and basswood are also abundant in this region, and reach an immense size. In fact, finer groves of maple it would be difficult to find in any part of the State.

The pine country proper lies between the two tracts we have thus described, and embraces about 15,000 square miles. It is composed largely of sand hills and plains, either scantily furnished with vegetation, or densely covered with pine forest. Argillaceous tracts wooded with beech and maple also occur, like oases in a desert; and swamps abound, with the usual lowland timber. Forests of hemlock spruce are frequent, and there are occasional ridges of oak. Birch (*B. lutea*) also begins to be a common forest tree, and attains a large size. The usual timber of the barrens is Jack Pine (*P. Banksiana*). Climatic and other influences have combined to produce groves composed entirely of this species of large size and of great beauty, for, instead of being "a straggling shrub, or low tree" (Gray), it rises, often 50–60 feet, straight and symmetrical. All through this region *Pinus strobus* is the prevailing species and furnishes most of the lumber, but *P. resinosa* is frequent as far south as Clare county, and occurs sparingly in the northern part of Isabella county, which appears to be its southern limit.

Such is the general character of the sylva down to about latitude 43°, but in the western part of the State, owing perhaps to moister climate, or to favorable soil, hemlock spruce is more abundant, and reaches much farther south, nearly or quite to the Indiana line, and the same is true of white pine.

Portions of the counties of Clare, Missaukee and Roscommon represent an undulating plateau, which is 700–800 feet above the level of the great lakes, and has an interesting flora, as yet little studied. This region was examined in June, 1876, and revealed a number of northern plants. In the southern part of Clare county were found *Ledum latifolium, Kalmia glauca, Physalis grandiflora* (not before found south of the Upper Peninsula), *Corydalis glauca*, and *Geranium Carolinianum*—the two latter species growing luxuriantly in the deep woods, after fires. In the shade of the Jack Pines grew *Prunus pumila, Potentilla tridentata* (not before observed in Lower Peninsula), *Krigia Virginica, Arctostaphylos Uva-ursi, Linaria Canadensis, Kœleria cristata, Carex Houghtonii*, etc., etc. Near Houghton Lake were found *Adlumia cirrhosa, Ribes lacustre, Dracocephalum parviflorum, Streptopus roseus*, and *S. amplexifolius;* and in Muskegon river, near its source, *Potamogeton lucens. Pinus resinosa* was noticed frequently, growing with common pine, and near the center of Clare county it became more abundant, forming groups. Single individuals stretch upwards 150–160 feet, their clean, copper-colored boles often rising 100 feet to the first limbs.

The flora of the deep pine woods is interesting, though rather monotonous. Very little undergrowth is found, and their gloomy recesses nourish only such plants as love thick shade. Here the club-mosses (*Lycopodiums*) find a congenial home, and flourish luxuriantly, while *Clintonia borealis* covers the ground. The great round-leaved orchid (*Habenaria orbiculata*), with its tall, greenish spike and twin leaves close to the earth, is also frequent and striking. We shall also meet *Mitchella repens, Smilacina bifolia, Trillium grandiflorum*, perhaps, and a few ferns, particularly *Asplenium Filix-fœmina*, and *Phegopteris Dryopteris.* Other species occur, of course, but not so abundantly. In more open places, and on ridges, we meet *Rhus aromatica* and *Comptonia* along with wintergreen (*Gaultheria*) and trailing arbutus (*Epigea)*, and are often fortunate enough to find the wax-white, fragrant flower of *Moneses uniflora* or *Polygala paucifolia*, hiding its shining leaves under a wealth of showy pink blossoms.

The floral treasures of the pine region lie, however, in its swamps and lake borders rather than in the deep woods. Therein grows *Linnea borealis* in all its delicate beauty, carpeting the ground, and close at hand, the odd, brown-purple flower of *Cypripedium acaule* and the small yellow blossom of its water-loving relative *C. parviflorum.* In such swamps, or within a stone's throw of them, may be found many other plants of equal interest, such as *Medeola Virginica, Ledum latifolium, Andromeda polifolia, Kalmia glauca, Lonicera oblongifolia, Cardamine pratensis, Gerardia aspera, Mitella nuda, Eriophorum vaginatum*, etc. On lake margins we shall find *Lysimachia* and the blue *Pontederia* and more rarely, *Nesœa* and *Eleocharis quadrangulata.* The lake itself, most likely, will be full of *Nymphœa, Nuphar, Utricularius*, and a world of *Potamagetons* and similar water weeds. Shrubby *Vacciniums* line the bluffs, and here and there gleam the white trunks of paper birches against the dark background of pines.

In the thick-pine country, where the lumberman's axe has let in the sunlight, new plants spring up freely. Here, *Prunus Pennsylvanica* and poplars are frequent, and the blackberry is omnipresent. *Aralia hispida* and *Physalis pubescens* are also peculiar to such land, and in August *Gnaphalium decurrens* may be seen whitening thousand of acres.

One seldom beholds a drearier sight than a dead and deserted lumber region. The valuable trees were all felled years ago, and the lumberman moved on to fresh spoils, leaving behind an inextricably confused mass of tree tops, broken logs, and uprooted trunks. Blackberry canes spring up everywhere, forming a tangled thicket, and a few scattering poplars, birches, and cherries serve for arboreal life, above which tower the dead pines, bleached in the weather and blackened by fire, destitute of limbs, and looking at a distance not unlike the masts of some great harbor. Thousands of such acres, repellant alike to botanist and settler, can be seen in any of our northern counties.

In certain districts considerable beech is found associated with the pine. The soil of such tracts is usually of better quality, and can be rendered productive without much labor. It may be noticed that in such cases the pine also grows thriftier and makes better lumber.

Sections of this and the Traverse region of Michigan are still sparsely settled, or not at all, and have been visited rarely by botanists. Consequently, we may expect many editions to our flora, as well as corrections, when this region is as thoroughly known as the south half of the State now is; our ignorance, rather than nature's parsimony, explaining why we have so few species credited to us. The most promising field for the botanist evidently lies in the Houghton Lake region and northward, and in the upper Peninsula, many parts of the interior of which are botanically unknown.

Our flora, as here presented, contains in all 113 families (orders), and 1,634 species. The composites claim the largest number of species, 182—about one-ninth of all. Sedges follow with 176 species; grasses, 139; rosaceæ, 61; ferns, 56; leguminosæ, 55; figworts, 46; mints, 40; mustard and crowfoot, 39 each; heath family, 35; and umbelliferæ, 27. We have 165 trees and shrubs, about 20 of which are valuable timber trees. At least 40 of our trees and shrubs are worthy of cultivation for ornament. Sugar maples and elms are commonly planted, while the tulip tree, basswood, Kentucky coffee tree, black walnut, and butternut, among deciduous trees, and hemlock, white pine, black spruce, arbor vitæ, and red cedar, among evergreens, deserve more attention. About 20 species of woody and herbaceous native climbers are frequent, and some are worthy of cultivation, (see State Pomological Report of '79 for a list.) Ninety medicinal plants are admitted into the U. S. Pharmacopœia, 45 belonging to the primary list, and an equal number to the secondary, while a number of others deserve attention at the hands of Pharmacists.

It may be stated in conclusion that, in the preparation of this catalogue, we have spared no pains to make it thoroughly reliable, a majority of the species enumerated having passed through our hands, and the remainder being admitted only on good authority. We have preferred to make a *useful* rather than a a *large* catalogue, and, on this ground, we have rejected a number of species, some of which may yet make good their claim to be considered as part of our flora. We cannot hope to have escaped all errors, and crave charitable judgment for any such the kind reader may discover, trusting that they may be found errors of omission rather than of commissio[illegible]

In [illegible] arrangement of orders, we have preferred, as mor[illegible] [illegible]nvenient, to follow the 5th edition of Gray's Manu[illegible] rather than later works. The vexatious subject of synonomy has received considerable attention, and will, we believe, be found brought down nearly to date. Further observations will be published from time to time in the form of addenda, towards increase of which we solicit correspondence and contributions from all parts of the State.

IONIA, MICH., January 20, 1881.

DISRUPTION OF PLANETARY MASSES FROM THE PRIMEVAL NEBULA.

V.

By EDGAR L. LARKIN.

It has been shown in this series that the gaseous sphere could not have parted with any form of ring known to geometers. All varieties of segmental rings were examined, and their displacement found impossible by known laws of mechanics. The nebula subsided from space to the dimensions of the orbit of Neptune, else its assumed rotation could not have been equal to the orbital velocity of that planet.

Indeed, it must have revolved faster, for matter along the line of the centre of gravity of the ring moved with the rate that Neptune now has. Then the outside of the ring moved faster and the inside slower than the Neptunian velocity. But the inside was required to move with greater rapidity than any other point to exceed attraction and disrupt the mass. From this consideration alone the doctrine of ring detachment is subverted.

We are now to demonstrate that no particle whatever can be detached from a revolving sphere whether gaseous, fluid or solid, by any force known to man. Tangental force in no case overcomes radial, being unable from known physical laws, which teach that not an atom ever left a rotating cosmical mass. We have made calculation of the maximum effect of tangental force on matter on the equator of the sphere when coincident with the orbit of Neptune, radius being 2,780,000,000 miles. And if the solar parallax is modified, bringing Neptune somewhat nearer, the figures will not be in material error. It is a law of mechanics that if matter is thrown off the periphery of a revolving sphere by force evolved by rotation, the detached portion always, when maximum power is exerted, traverses a line tangent to the curvature at the point of departure. If a revolving globe should burst, the pieces would be projected along tangental lines and never rise higher. But what is a tangent to the Neptunian orbit, and what is its departure from the curvature of that mighty sphere whence Neptune's mass is said to have been detached? It is apostulate of the Hypothesis that the nebula was a sphere, else it could not have parted with matter in the form of a ring. We adopt the idea that it was round, and for the purposes of trigonometry imagine the surface to have been as level as still water. We are in search of the departure of the tangent from the curve at different distances along the equator, to learn how far tangental force was able to project matter above the periphery.

The length of 1″ of arc on the equator of the nebula was 13,478 miles, and we made selection of 8″ of arc or 107,824 miles to find the amount of its deflection from the tangent. The curvature cannot be detected by tables of logarithmic functions carried to the sixth decimal place—thus:

$$\begin{array}{lr} \text{log. sin. } 1' = & 6.463726 \\ \text{log. } \quad 60 = & 1.778151 \\ \hline \text{log. sin. } 1'' = & 4.685575 \\ \text{log. } \quad 8 = & .903090 \\ \hline \text{log. sin. } 8'' = & 5.588665 \\ \text{and} & \\ \text{log. tan. } 1'' = & 4.685575 \\ \text{log. } \quad 8 = & .903090 \\ \hline \text{log. tan. } 8'' = & 5.588665 \end{array}$$

That is, the logarithmic sine and tangent of 8″ are the same; hence the arc cannot be told from a straight line by ordinary tables. This being the case, radii drawn to the centre from each extremity would be equal in length, and it follows that any particle of matter on the equator of the primeval sphere, after having traversed more than a hundred thousand miles under the influence of tangental force, was no further from the centre than when it started, making the formation of a ring, or detachment of an atom, alike impossible.

Not deeming it true that an arc of such length had no curvature, and not having logarithmic tables for exact computation of functions near their limits, we were obliged to use the cumbersome method of natural sines, cosines and tangents, carrying the calculation to the twentieth decimal place to secure accuracy.

To find the cosines of such minute arcs use was made of the formula—Cos.$=1-\frac{1}{2}$ sin.^{2}, and for secants—Sec. A$=\frac{1}{\cos.}$A.

Applying these formulæ to the arc of 8″ it was found that the secant was only 1.94 miles longer than the radius. That is, the curvature of the sphere at any point distant 107,824 miles from another, made a point of tangency, is less than two miles! Let us watch the career of an atom destined to be cast off the equator to

become a part of the Neptunian ring. Conceive the sphere at rest; let some unknown law cause it to rotate, with constantly accelerating velocity, until finally equatorial atoms are moving so fast that tangental force just counteracts gravity. The particles will be balanced and without weight. Increase rotation, and the atoms will move on a tangent instead of the surface of the sphere.

But they had to move 50,000 miles before it could be determined whether they were traversing the periphery or tangent, and over 50,000 more miles in order to attain an elevation of two miles! To do this the maximum force was required, as it alone was able to project matter to the tangent.

Nothing in nature can exceed the feebleness of this maximum tangental force. An atom on the equator required 8h. 54m. to traverse 107,000 miles, and then it was not quite two miles further from the centre. Yet this gentle force cast off a ring whose mass was 102 sextillion tons, if the Hypothesis is true.

No theory ever advocated concerning the development of the planets has so little in its favor as that of ring detachment. Below is a table showing the increase of distance of equatorial atoms from the centre of the sphere after having traversed different arcs from the point where they became balanced between the opposing forces, centripetal and tangental.

The first column gives the arcs, the second their length in miles, and the third shows the gain in distance from the centre of the nebula, after reaching the extremity of arcs, providing the matter touched the tangents.

Arcs.	Length in Miles.	Altitudes of Matter in Miles.
8″	107,824	1.94
10″	134,780	2.78
15″	202,170	7.
25″	336,950	20.
1′	808,671	117.
10′	8,086,710	11,759.
1°	48,520,266	417,061.

But no atom could rise above the periphery, for the entire periphery itself would rise. Thus, let a particle become subject to tangental force and fly along a tangent. Let the force be enormous, sufficient to hurl equatorial matter along a tangent of 1° or 48,520,666 miles, and it will then be 417.061 miles more distant from the centre. The next atom behind would follow and all others on the same line around the sphere. The next inner particle would become elevated, and the next until the space 417,061 miles filled with gas, the result of the process being that the equatorial diameter of the nebula increased 834.122 miles. But this diminished rotation allowed gravity to regain dominion and bring down the protuberance to a level as before. This mutation must obtain in all rotating masses so long as they remain gas or liquid, the areolar velocity being a constant. During the ascent and fall of the equatorial matter it is seen that no particle wandered away, but every one returned at the command of gravity. When a mass solidifies its rotary velocity cannot accelerate, and since matter is unable to part from a fluid sphere it cannot possibly leave a solid. Hence no cosmical mass, whatever its size, density or rate of revolution, ever detached an atom by force generated by rotary motion. Suppose the nebula received an impulse that imparted inconceivable velocity of revolution, causing peripheral matter to rush on a tangent of 20°, flattening the mass into the shape of a bi-convex lens, then rotation must have almost ceased, when gravity reasserted mastery. Let one imagine himself to have been placed on the equator of the nebula, assuming the gas visible, which was not the case. An ordinary tree could then be seen with a telescope at a distance of 50.000 miles! The top of a common terrestrial mountain would have been in sight at a distance of more than 100,000 miles! The observer would have found himself in the midst of a mighty plain, and would have been able to see mountains a hundred thousand miles in every direction, so slight was the curvature. At a distance of 1° or 48,000,000 miles the depression below a tangent was only 417,000 miles. The diameter of the sun is 852,000 miles; therefore, if it were placed on the circumference of the primeval sphere, its semi-diameter could be seen at that enormous distance. Reverse nature's laws, making it possible that tangental force can disrupt a revolving mass, then with the sphere's known rotation of 3.36 miles per second (admitting the Hypothesis true) could a ring have been abandoned? Could the rotary motion even cause currents to flow from the latitudes to the equator, or even produce an equatorial elevation in so vast a level capable of detection by some distant micrometer? We answer no, because Neptune, with the same velocity, keeps on its orbit. We fail to see why the theory of ring displacement was ever entertained, since no analogy in nature suggests it.

New Windsor Obs., *Aug.* 8, 1881.

MICROSCOPICAL TECHNOLOGY.

Dr. Carl Seiler's Methods.

MOUNTING.

For mounting, both resinous and aqueous solutions may be used, which each possess advantages over the other, and for this reason a controversy has been going on for some time, between eminent microscopists, in regard to the advantages of glycerine, on the one hand, representing the aqueous mounting media and balsam, on the other, representing the resinous class. The truth is, that both should be used, as occasion requires. Glycerine, or its equivalents, should be used when it is desired to bring out delicate striæ, lines, hair-like projections, such as cilia on the epithelium of the respiratory tract, processes of the ganglionic nerve cells, and so forth, and for delicate vegetable preparations. Balsam should be used when clearness and transparency of the object, and brilliancy as well as durability of the staining is desired.

In order to clearly understand this the student will do well to mount two preparations of the same tissue, the one in balsam, or other resinous medium, and the other in glycerine or its equivalent, and then compare the results. He will find that the one medium is better suited for a particular preparation than the other.

Balsam. Among all resinous substances Canada balsam is the best for mounting purposes, provided it has been properly prepared. To do this, take a clear sample of balsam and evaporate it in a water bath, to dryness, that is, until, when hot, all odor of turpentine has disappeared, and, when cold, it is hard and brittle, like resin. This will take several days; and great care should be exercised in keeping the water bath full of water, for as soon as the temperature in the balsam is raised above 212° F. it turns brown, and is then unfit for use.

When thus evaporated the balsam is again heated in the water bath and enough of Squibb's absolute alcohol is added to dissolve it and make the solution of the consistency of thin syrup. It is now allowed to cool and poured into a spirit lamp, the wick having been removed, in which it is kept for use, the glass cap of the lamp protecting it from dust and preventing the evaporation of the alcohol. If, after using for some time, the solution becomes too thick, it should be warmed by placing the spirit lamp in warm water and adding to it some warm absolute alcohol. If the alcohol used in dissolving the balsam or in diluting the solution is not strong enough, a white precipitate will form, which may be redissolved by the application of heat, but will reappear when exposed to the air, in a thin layer on the

slide, and the solution thus becomes useless for mounting.

Having cleaned his slides and covers, and having his balsam solution prepared, the student may now proceed to mount the objects in the following way: Place one of the stained sections which have been kept in alcohol in a small shallow dish containing some absolute alcohol, and allow it to remain there for some minutes, so as to remove all traces of water which may remain in it from the staining fluid and which have not been removed by the washing in the weaker alcohols. Then float it on the surface of some oil of cloves, also contained in a shallow glass or porcelain dish, until it has become transparent, when it should be removed from the oil, spread out on a glass slide and covered with a thin cover glass which has been taken from the bottle filled with alcohol and wiped dry with a soft rag. The specimen is now ready to be examined under the microscope, in order to see whether it will pay to permanently mount it in balsam. If found good the cover glass is carefully removed and all superfluous oil remaining on the section and on the slide is taken up with the edge of a piece of blotting paper, the object covered with a drop of the balsam solution, a fresh, dry cover is placed upon it, taking care to exclude any air bubbles, and pressure is made upon the cover to press out all superfluous balsam. In order to prevent the formation of air bubbles in the specimen the cover should be held by the forceps, near the edge, the opposite edge should be carefully placed into the balsam and the cover gradually lowered over the section until it lies flat upon it. If, after pressing the cover down, it is found that the balsam does not extend to the edge of the cover all round, a small drop of balsam should be placed near the edge, at the point where the balsam under the cover joins the empty space, when it will run in by capilliary attraction. The slide is then laid aside to allow the balsam to dry spontaneously, which will take place in from four to six weeks, or it may be placed in a drying oven, the temperature of which is not raised above 130° F., when it will be ready for finishing in a much shorter time. An excellent apparatus of this kind is sold by dealers in microscopical appliances. It consists of a box of copper containing movable trays, surrounded by another larger box, also of copper, so that a space remains between the two boxes, which, when the oven is used, is filled with water through an opening at the top. A thermometer is inserted through this opening, and a lamp is placed under the outer box, which raises the temperature of the water up to any desired degree, and thereby warms the air in the inner box. A current of air is established through the inner box by ventilators, both at the top and bottom. Specimens which have been double stained with indigo should not be exposed to either heat or sunlight, as they will fade under these circumstances.

The fact that the oil of cloves or other volatile oils which may be used in its stead shrink many of the more delicate tissues, and the difficulty attending the removal of large thin sections from one solution to the other, as well as the danger of tearing while they are spread upon the slide, has led the author to discard the oil of cloves as a clearing agent, and to adopt a plan of mounting in balsam, which avoids all these dangers and which has the advantage that the slides may be finished immediately.

MOUNTING IN BALSAM.

After one of a number of sections which have been stained together has been examined in oil of cloves, and has been found to be good, the others may be inferred to be also good and worth mounting. One of them is placed in absolute alcohol, and after it has remained therein for some time, is floated upon a cover glass, which need not be wiped dry after taking it from the bottle of alcohol in which the covers are kept, held in a pair of forceps whose ends have been bent so as to stand at right angles to the shafts, and to close on top of each other. The cover with the section on it is then lifted out of the alcohol, when the specimen will be found to be evenly spread out, needing but little unfolding at the edges, which sometimes fold over; the lower surface is to be wiped dry and a drop of the alcoholic solution of balsam is placed on the section, which, on the cover, is set aside in a place free from dust, to clear up and allow the balsam to get dry. After fifteen or twenty minutes another drop of balsam should be placed upon it, in order to prevent the drying of the tissue. After twelve hours the balsam has dried sufficiently on the cover so that the specimen can be mounted, in the following manner: Take the cover up with a pair of forceps and place a drop of crude benzole* on the balsam and quickly place the cover, with the balsam down, on a clean slide, as near the centre as possible, and taking care to avoid air bubbles. Then warm the slide over a spirit lamp, place on a turn-table and quickly centre the cover so that its edge does not seem to shake when the slide is rapidly revolved. Next run a ring of cement around the edge, as will be described presently, and then press gently upon the cover, to cause the section to lie flat, and to press out the surplus of balsam, which, with a little management of the pressure, will run into the ring of cement. Another ring of cement may then be applied, when the slide is ready to be labeled and put away.

The cement for balsam mounting which is most satisfactory was devised by Mr. T. W. Starr, of Philadelphia, and is prepared as follows:

Clear Canada balsam,	370 grains.
Deodorized benzine,	140 grains.
Spirits turpentine,	120 grains.
Gum dammar,	185 grains.

Mix the balsam and benzine well together in a bottle, then add the turpentine and shake until mixed; finally, add the gum dammar, in selected pieces, and shake frequently till dissolved. If necessary, the solution should be filtered through absorbent cotton, previously moistened with turpentine. A portion of this is to be placed in a small glass-capped vial, to the cap of which is attached a small *sable* brush, which will come to a point, the ordinary camel's hair brush not being suitable for ringing, as it spreads too much. If the solution is too thick to flow readily it should be diluted with spirits of turpentine until the proper consistency is obtained. This fluid is also an excellent mounting medium when the object has previously been cleared in oil of cloves or turpentine. For ringing, this cement may be colored by adding to it a few drops of alcoholic solution of aniline of any shade desired, or it may be mixed with white zinc, when the resulting ring will appear as if made of porcelain.

The specimen to be ringed is placed upon the turn-table, and if any balsam has soiled the slide or the cover it must be removed by scraping with a sharp knife and afterward wiping with a soft linen rag wet with benzole. As a matter of course, the balsam should be hard, so that the cover will not be displaced by the scraping and wiping. If the cover should not be in the centre, and a self-centering turn-table is used, the slide is to be warmed until the balsam becomes soft, when the cover may be centered on the turn-table. Having thus prepared the slide, the brush in the cement bottle is removed and the surplus scraped off, so that it is almost dry; with the left hand the turn-table is spun round rapidly and the point of the brush applied to the edge of the cover for a moment only, holding the brush slanting in

*The refined benzole or benzine, which is frequently sold for benzole, is to volatile for our purposes.

the right hand, and that hand resting upon the stand of the table. The brush is then moistened a little more with the cement and again applied to the edge of the cover, without, however, allowing the hair of the brush to touch the glass; the small drop at the point of the brush only should be in contact with the glass and be carried around by the rapid spinning of the turn-table. The slide is then set aside so as to allow the ring to become thick by evaporation of the benzine and turpentine, when the applications of cement may be repeated until the desired thickness is obtained.

If colored or white zinc cement is to be used it should not be applied until after the first rings of clear cement have become hard, as otherwise the colored cement will run in under the cover and be disseminated among the mounting medium. If white zinc cement has been used, it may be still further improved by running one or two fine lines of asphaltum varnish around it, but not before the cement has thoroughly hardened.

The making of a neat ring around the edge of the cover is an art which can only be acquired by practice and experience, and therefore a few hints in regard to the causes of failure will greatly help the beginner.

If the ring, when finished, shows irregularties both at its inner and outer edge, the cement used is too thick and should be diluted with turpentine. If the ring is too broad—wider than about one-thirty-second of an inch, unless intentionally widened—the brush has been pressed down too hard upon the glass, which causes it to spread, or too much of the cement has been applied at once. This is especially the cause when irregularities or bulging in the edges of the ring are noticed.

If the ring is filled with minute air bubbles, the brush has been kept too long in contact with the glass in making the first ring, or its point has been brought in contact with the first ring in making the second application, when only the minute drop should have touched the glass; or, finally, the solution may be too thick.

MOUNTING IN GLYCERINE.

When a preparation is to be mounted in glycerine, it should, after having been stained, be placed in dilute glycerine for twenty-four hours, and then for the same length of time in strong glycerine (Bower's), in order to make it transparent. The section is then carefully spread upon the slide; a clean cover, which has been wiped dry, is placed upon it and pressed down, to remove the excess of glycerine from under the cover, and a small spring-clip is applied, so as to hold the cover in position during the subsequent manipulation of washing. The excess of glycerine must now be removed as carefully as possible by washing it off with a stream of water, either from a syringe or from a tap, taking care not to displace the cover in doing so. The slide is then stood on edge to dry, the spring-clip still holding the cover, and when all the water has evaporated it is ready for ringing. In order to do this the spring-clip must be removed, the slide placed upon the turn-table, the cover centered and a ring of some water-proof cement applied, in the manner described above.

The best cements for this purpose are, first, the so-called Bell's cement, which may be obtained from any dealer in microscopical supplies, and the composition of which is a secret with the makers; and second, the author's gelatine cement, which is prepared as follows:

Take of—

Coxe's gelatine,	2 drachms.
Gum ammoniac,	10 grains,
Acetic acid, No. 8,	1 ounce.

Dissolve the gum ammoniac in the acetic acid and filter through absorbent cotton; then warm the acid and gum solution by placing the vessel containing it in a water bath and add the gelatine, stirring until it is dissolved, when the resulting solution should be filtered or strained through muslin. After a ring of this cement has been made around the edge of the cover, and has become set, it should be painted over with a solution of bichromate of potash in water (ten grains to the ounce) and exposed to either sunlight or ordinary daylight. The action of the light is to make the chromate of gelatine which has been formed insoluble and thus perfectly waterproof. After this gelatine cement ring has become hard, it should be covered with a ring of white zinc cement, when it will be found that none of the glycerine will leak out, even after the specimen has been kept for years.

If thicker pieces than thin sections, such as pieces of the mucous membrane of the intestine or bladder of animals, are to be mounted in glycerine or other watery medium, a cell must be employed. This consists of a ring made of either glass, rubber, metal or cement, and which is high enough to prevent the cover-glass from pressing upon the specimen when mounted. In order to do so, the ring, if it be of glass, rubber or metal, is first cemented upon the slide with marine glue or the gelatine cement, and is accurately centered with the turn-table. If the cell is to be made of cement a ring of the required diameter (which must be a little smaller than the diameter of the cover-glass) is spun upon a slide in the same manner as was described for applying the ring to the edge of the cover in finishing slides, and is built up to the required height by repeated applications of the brush. It should then be set aside to dry and harden. Any of the cements may be used for this purpose, provided they will stick well to the glass.

Just before mounting the top of the ring forming the cell must be moistened with gelatine cement; the specimen, which has been made transparent by soaking in glycerine, is then placed in the centre of the ring, enough glycerine is added to fill the cell and the cover is applied. If an air bubble is left under the cover the latter must be lifted up and more glycerine must be added; if, on the other hand, too much liquid has been used, the surplus must be washed off, as described above. A ring of gelatine or Bell's cement is next spun around the edge of the cover, in order to seal up the cell, and it is then finished with white zinc cement.

An excellent substitute for glycerine is Farrant's solution, which combines all the advantages of glycerine and some of those of balsam, inasmuch as it has nearly the same index of refraction as glycerine, and becomes hard like balsam, doing away with the necessity of a waterproof cement. The formula generally given in the text-books for this solution is not correct, and the author has found that the following formula is more satisfactory:—

Picked gum arabic,	4 drachms.
Camphor water,	4 fl drachms.
Glycerine,	2 fl drachms.

Dissolve and strain through muslin.

Specimens to be mounted in this medium must first be made transparent by soaking in strong glycerine, and may then be mounted as though the solution were a resinous mounting medium. Great care should be taken to exclude air bubbles, as they cannot afterward be gotten rid of. This medium is especially adapted for delicate animal membranes and soft vegetable tissues.

Some specimens, especially vegetables, such as seeds, pollen grains, sections of wood, etc., may often with advantage, be mounted dry, *i. e.*, without much previous preparation, and without any mounting medium, but they must then be examined as opaque objects, and must be viewed by reflected light.

If an object is to be thus mounted, a disk is painted with asphaltum varnish in the centre of the slide, which is spun around upon the turn-table while applying the brush with varnish. A disk of dead black paper may

be pasted upon the slide, instead of the disk of varnish, to serve as a dark background. A cell ring is then applied around the edge of the disk, and the object is fastened in the centre of the cell by means of mucilage or glue. This done, the cover is placed upon the ring and cemented down as descibed above.—(*Compendium of Microscopical Technology.*)

THE DEARBORN OBSERVATORY.

The annual report of the Board of Directors of the Chicago Astronomical Society, together with the report of the Director of the Dearborn Observatory, dated May, 1881, is now published.

The first report is brief, and states that the Society has entered into a contract with the city of Chicago for furnishing standard time to the City Hall. In order that this contract may be more satisfactorily fulfilled, the Directors of the Society have ordered from Messrs. Howard & Co., of Boston, two new clocks, which will cost about $1000. The cost of running wires and other equipments has been $574.

The friends of the Society have contributed the funds required to meet the immediate wants of the Observatory, but the Society reiterate the often-repeated call for a permanent endowment, which will not only enable it to continue its present course of action, but to enlarge its sphere of astronomical work and take an honorable place among the prominent astronomical Observatories of Europe and America. The Directors express a hope that the time has arrived when the public-spirited citizens of Chicago will contribute the amount to accomplish this object, and we heartily trust that the confidence expressed in this respect may receive a prompt confirmation. The Dearborn Observatory is built and equipped with one of the finest equatorials in the United States; the question of endowment is therefore one which calls for immediate action.

In the second report Professsr G. H. Hough states the nature and amount of the astronomical work carried on at the Dearborn Observatory during the past year by himself and Messrs. Elias Colbert and S. W. Burnham.

The planet Jupiter has received the attention of a large number of astronomers during the past two years, especially of amateurs, and much writing of a miscellaneous character has appeared on the subject. As the proper study of markings and spots on celestial objects require the use of a telescope of great optical power, combined with good definition, the following report of observations on the planet Jupiter, made with the Dearborn equatorial, which possesses these conditions, will be read with interest, especially as they do not confirm many observations made under less favorable circumstances.

The planet Jupiter was made a special study during the past year. The first observation was secured on May 6, 1880, and the last on January 30, 1881. During this period the various spots and markings on his disc were subjected to micrometer measurements whenever practicable. It is readily apparent to any one who has examined contemporaneous drawings or sketches made by different observers and telescopes, that they are generally unreliable, unless based on micrometer measurement, and frequently give rise to erroneous deductions with regard to the phenomena in question. We believe the time has passed when mere estimations or sketches are of value in any department of practical Astronomy. Jupiter presents such a variety of phenomena on his disc, at different times, that it has been accepted as an established fact that his surface is subject to sudden and rapid changes, which may be accomplished in a few days or even a few hours.

The observations made at the Dearborn Observatory during the past two years does not confirm this statement. On the contrary, all minor changes in the markings or spots have been slow and gradual, such as might be produced by the operation of measurable mechanical forces. In fact, the principal features have been permanent, no material change being detected by micrometer measurement.

The following is a summary of the observations on Jupiter:

GREAT RED SPOT.

Longitude,	37 nights	560 measures.
Latitude,	12 "	34 "
Length,	20 "	67 "
Breadth,	10 "	32 "
Position of maj. axis,	5 "	16 "
Total		709 "

EQUATORIAL BELT.

Observed on 26 nights—

Position of the North Edge	87	measures.
Latitude " "	34	"
Width of the Belt	53	"
Total	174	"

EQUATORIAL WHITE SPOTS.

Observed on 18 nights—

Longitude	240	measures.
Latitude	15	"
Total	255	"

POLAR SPOTS.

Observed on 22 nights—

Longitude	144	measures.
Latitude	40	"
Total	184	"

Being a total of 1,379 micrometer measurements.

From the micrometer measurements for longitude of spots, the equatorial diameter of the planet is deduced on 50 different nights, and from the latitude measures, the polar diameter on 13 nights.

The following deductions have been drawn from these observations.

ROTATION OF JUPITER.

The period of the planet's rotation, as obtained by different observers, has varied between $9^h\ 49^m$ and $9^h\ 56^m$. The observations made on the great red spot during the opposition of 1879, gave for the rotation period about $9^h\ 55^m\ 34^s$; being 8 seconds greater than the previously accepted value.

The discussion of our longitude measures on the great red spot, made from September 25, 1879, to January 27, 1881, comprising a period of 490 days, gives for the mean value $9^h\ 55^m\ 35.2^s$.

When the individual observations are compared, however, with this value, there is found to be a well marked maximum displacement of the center of the spot amounting to $1''.4$ of arc, indicating that the center gradually oscillated to this extent in longitude, corresponding to an actual displacement on the surface of Jupiter 3,200 miles.

The observations are all well represented by making the rotation period depend on some function of the time.

The period $9^h\ 55^m\ 33.2^s + 0.18^s \sqrt{t}$ satisfies all the observations with a mean maximum error of $0''.5$ of arc. In which the zero epoch is September 25, 1879, and t is the number of days after that date.

This formula gives for the rotation at the date January 27, 1881, $9^h\ 55^m\ 37.2^s$, agreeing essentially with the value deduced directly from the observations made during the two months previous to that date.

The rotation period derived from the observation of polar spots was as follows;

	Latitude.	Longitude.	Interval Between Extreme Observations.	Rotation.
White Spot	+10″.46	$3^h\ 00^m$	2 months.	$9^h\ 55^m\ 39.3^s$
White "	−11″.62	$3^h\ 57^m$	2 "	31.0^s
White "	−11″.62	$4^h\ 26^m$	2 "	33.6^s
Black "	+10″.40	$0^h\ 00^m$	2 "	31.0^s
Black "	+ 9″.70	$2^h\ 22^m$	1 "	40.5^s
Mean of all	--------	--------	--------	$9^h\ 55^m\ 35.1^s$

The latitude is simply the measured distance north or south of the Jovian equator, reduced to the mean distance of the planet from the earth. The zero of longitude is the center of the great red spot.

The white spots were egg-shaped, about 1″ of arc in length, and were only visible under favorable atmospheric conditions.

The rotation period derived from the small spots indicates an average displacement during two months of 2″ of arc, or 4,600 miles, or an average drift in longitude of nearly 3 miles per hour.

ROTATION FROM EQUATORIAL SPOTS.

From July 8 to October 1, 1880, comprising a period of 85 days, the longitude of a white spot, between the equatorial belts, in latitude 2″.3, was observed on 10 nights. The rotation, as deduced from this spot, was $9^h\ 50^m\ 00.56^s$, representing all the observations within 0″.3 of arc, showing that the motion, so far as we know, was absolutely uniform. From October 28, 1880, to January 30, 1881, during a period of 94 days, another white spot, in latitude 2″.8, and differing 20 deg. in longitude from the first, was observed on 8 nights.

The rotation was $9^h\ 50^m\ 09^s.8$, with uniform motion.

If the great red spot is supposed fixed, then the mean drift of the equatorial spots would be about 270 miles per hour in the direction of the planet's rotation, or the spot made a complete revolution around the planet in about 42 days.

The approximate diameter of the equatorial white spots was 1″.2 of arc, or 2,800 miles.

These observations leave the true period of the rotation of Jupiter in a very unsettled condition. The great red spot was frequently measured to ascertain whether it was subject to any marked change, in position, size or shape.

The following are the mean results for the two oppositions of 1879 and 1880, reduced to the mean distance of the planet from the earth :

	1879.	No. of Obs.	1880.	No. of Obs.
Length	12″.25*	9	11″.55	20
Breadth	3″.46	8	3″.54	10
Latitude	6″.95	8	7″.14	12

* Re-computed with the constants of 188 .

The position of the major axis of the spot was measured as follows, the number indicating the inclination of the axis of Jupiter's equator as compared with Marth's ephemeris.

1880, July 27 + 2°.3
" Aug. 6 + 2°.5
" Sept. 4 + 2°.9
" Dec. 3 + 2°.2
1881, Jan. 17 — 0°.8. Definition poor.

These numbers indicate a remarkable degree of permanency with regard to the size, shape and position of the spot, during the two oppositions. Our observations do not warrant the assumption of any considerable change since September 25, 1879.

The actual size of the object, as seen with our telescope, was as follows :

Length, 29,600 miles.
Breadth, 8,300 "

The smaller telescopes make the approximate length considerably less than the real value.

POLAR BELTS.

During the opposition of 1880 the polar belts were not as sharply defined as during 1879, with the exception of Nos. 2 and 3, the latter of which became very conspicuous. During the month of June, when the planet was at about mean distance, no trace of polar markings could be seen. And it was not until July 4, when the distance was 0.948, that the belts 2 and 3 were barely visible. Markings on the southern hemisphere were first seen on July 24, when the distance of the planet from the earth was 0.888.

The latitude of 2 and 3 was as follows :

	1879.	1880.
No. 2,	+ 9″.78	+ 9″.75
No. 3,	+ 5″.98	+ 5″.89

EQUATORIAL BELT.

The great equatorial belt remained without any material change in size or position, as the following measurements will show :

	1879.	1880.
Latitude N. Edge,	+ 2″.59	+ 2″.35
Width	6″.77	7″.04

During both years the position of the north-edge was parallel to Jupiter's equator, as given in Marth's ephemeris.

PHENOMENA.

When a satellite crosses the disc of the planet it usually disappears in our telescope, when one-fourth to one-third across the disk, and reappears at an equal distance from the preceding limb, proving that the center of the disc is more luminous than the satellite.

In the case of the first satellite, it is sometimes seen to transit as a grayish spot, and remains visible when on the middle of the disc ; such a phenomenon was observed on December 10, 1880.

On July 3, 1880, the second satellite during transit passed almost directly over the center of the great red spot, when it appeared sensibly as bright as when off the disc.

On November 1, 1880, I had the good fortuue to witness the transit of the shadow of the second satellite over the center of the red spot, and, at the same time, the transit of the shadow of the first satellite over the disc of the planet.

The shadow of the satellite, when fully projected on the red spot, was distinctly visible, but not quite as black as the shadow on the disc, proving that the red spot, although much less luminous than the disc, was yet much more luminous than the shadow.

THEORY OF JUPITER.

The generally accepted theory is, that the planet Jupiter is surrounded by a dense atmosphere, that the belts are the solid portions of the planet, and that the minor spots are clouds floating in the atmosphere. It is difficult, if not impossible, to reconcile the known phenomena with any theory yet proposed. But whether there are a sufficient number of well determined facts to form a better one, is doubtful.

Accurate observations are needed on the markings seen at different times on his disc ; not sketches and general statements, but suitable micrometer measurements, from which may be deduced the motions and changes taking place on the surface. And until this method is pursued there is but little hope of solving the problem of his physical constitution.

It has occurred to me, however, that the known phenomena might be explained in the following hypothesis, viz : the surface of the planet is covered with a liquid

semi-incandescent mass; that the belts, the great red spot and other dark markings, are composed of matter of lower temperature. The egg-shaped, polar white spots are openings in the semi-fluid crust. This hypothesis would account for the slow and gradual changes occurring on the surface, which does not seem reasonable on the simple atmospheric theory.

Over the liquid surface is an atmosphere in which is formed the equatorial white spots which are of the nature of cloud.

In conclusion the director expresses what we can well believe to be his sincere regrets at the loss of the valuable services of Mr. S. W. Burnham, who has accepted a position in the Washburne Observatory, at Madison, Wis. During the past year Mr. Burnham, as heretofore, had the use of the great equatorial for double-star observations, and reported the discovery since May, 1880, of about fifty new double-stars, all of which were measured at least three times. About one-half of the number are close double, not exceeding 1″.5 in distance. Among the more prominent stars are 9 persei, 5 persei, κ pegasi, γ foracis and 60 arietis. He also made about 600 measures on previously-known double-stars.

DR. COPELAND and Mr. Dreyer have been compelled to change the title of *Urania*, as it appears that name was appropriated by some *astrological* serial. In future, then, *Urania*, the astronomical serial, will bear the title *Copernicus*.

IT is rumored that Prof. Huxley will be asked to allow his name to be entered for the Linacre professor of physiology vacant by the death of Prof. Rolleston.

COMET (*b*) 1881.

The following observations of the Great Comet of 1881, made at Australian Observatories, have been kindly furnished for publication by Professor Wm. Harkness, U. S. N., to whom they were communicated by Mr. Todd, Superintendent of the Adelaide Observatory.

Date.		h.	m.	R. A. h.	m.	s.	Dec. South. °	′	″	Station.	* Of Comparison.
May	22,	—	—	4	58	—	35	30	—	Windsor...	B. A. C. 1573
"	23,	—	—	4	59	—	35	14	—	Melbourne.	Lacaille 1685
"	25,	—	—	4	59	46.	34	13	30.	Sydney....	----------------
"	26,	6	17	5	0	16.62	33	40	44.9	Melbourne.	----------------
"	27,	18	10	5	1	3.07	32	31	2.	Windsor...	Lacaille 1785
"	28,	8	0	5	1	25.	32	22	7.	Adelaide ..	Columbæ
"	28,	18	0	5	1	35.67	32	3	48.	Melbourne.	B. A. C. 1564
"	29,	5	39	5	1	48.52	31	42	42.	"	" 1615
"	29,	7	20	5	1	51.7	31	39	39.	Adelaide ..	" 1564
"	30,	7	33	5	2	21.8	30	51	2.	"	" 1615
"	30,			5	2	26.12	30	50	49.	"	----------------
"	31,	7	8	5	2	54.6	30	0	1.	"	----------------
"	31,	18	23	5	3	12.38	29	34	14.	Melbourne.	----------------
June	1,	5	25	5	3	26.26	29	6	40.	"	----------------
"	1,	6	48	5	3	32.8	29	2	58.	Adelaide ..	Washington 2173
"	3,	6	4	5	4	37.6	26	51	36.	Melbourne.	----------------
"	5,	6	10	—	—	—	24	5	—	Adelaide .	----------------
"	12,	6	0	5	11	38.4	8	11	39.	"	Rigel
"	12,	18	0	5	12	13.4	6	26	21.	"	τ. Orionis

		°	′	″			h.	m.	s.	
Windsor....	Lat.	33	36	29	S.,	Long.	10	3	21.8	E. of Greenwich.
Sydney	"	33	51	41	"	"	10	4	50.8	"
Melbourne.	"	37	49	53	"	"	9	39	54.8	"
Adelaide...	"	34	55	34	"	"	9	14	21.3	"

WASHINGTON, Aug. 9, 1881. W. C. W.

METEOROLOGICAL REPORT FOR NEW YORK CITY FOR THE WEEK ENDING AUG. 6, 1881.

Latitude $40^\circ 45' 58''$ N.; Longitude $73^\circ 57' 58''$ W.; height of instruments above the ground, 53 feet; above the sea, 97 feet; by self-recording instruments.

JULY AND AUGUST.	BAROMETER. Mean for the Day. Reduced to Freezing.	Maximum. Reduced to Freezing.	Maximum. Time.	Minimum. Reduced to Freezing.	Minimum. Time.	THERMOMETERS. Mean. Dry Bulb.	Mean. Wet Bulb.	Maximum. Dry Bulb.	Time.	Maximum. Wet Bulb.	Time.	Minimum. Dry Bulb.	Time.	Minimum. Wet Bulb.	Time.	Maxi'm In Sun.
Sunday, 31..	30.094	30.164	9 a. m.	30.044	9 p. m.	67.6	66.3	73	4 p. m.	69	12 p. m.	63	1 a. m.	63	1 a. m.	123.
Monday, 1..	30.060	30.096	9 a. m.	30.036	9 p. m.	74.3	70.3	80	3 p. m.	73	3 p. m.	68	5 a. m.	67	5 a. m.	140.
Tuesday, 2..	30.014	30.058	9 a. m.	29.966	6 p. m.	75.0	71.0	81	4 p. m.	74	5 p. m.	70	2 a. m.	69	2 a. m.	141.
Wednesday, 3 .	29.975	30.006	7 a. m.	29.942	4 p. m.	76.6	71.0	85	4 p. m.	75	7 p. m.	67	6 a. m.	67	6 a. m.	141.
Thursday, 4..	29.970	29.996	9 a. m.	29.940	6 p. m.	81.7	74.0	91	4 p. m.	79	4 p. m.	70	5 a. m.	69	5 a. m.	142.
Friday, 5..	29.930	29.976	9 a. m.	29.898	6 p. m.	82.3	75.6	91	3 p. m.	79	2 p. m.	75	5 a. m.	73	5 a. m.	141.
Saturday, 6..	29.864	29.914	7 a. m.	29.804	7 p. m.	83.0	76.3	91	2 p. m.	80	2 p. m.	78	12 p. m.	73	12 p. m.	139.

Mean for the week .... 29.986 inches.
Maximum for the week at 9 am., July 31st .... 30.164 "
Minimum " at 7 pm., Aug. 6th .... 29.804 "
Range .... .360 "

		Dry.			Wet.	
Mean for the week	....	77.2	degrees	....	72.0	degrees.
Maximum for the week,	at 2 pm. 6th	91.	"	at 2 pm 6th,	80.	"
Minimum "	" 1 am. 31st	63.	"	at 1 am 31st,	63.	"
Range "	" ---- ----	28.	"	....	17.	"

JULY AND AUGUST.	WIND. Direction. 7 a. m.	Direction. 2 p. m.	Direction. 9 p. m.	Velocity in Miles. Distance for the Day.	Force in Lbs. per Sqr. Feet. Max.	Force. Time.	HYGROMETER. Force of Vapor. 7 a. m.	Force of Vapor. 2 p. m.	Force of Vapor. 9 p. m.	Relative Humidity. 7 a. m.	Relative Humidity. 2 p. m.	Relative Humidity. 9 p. m.	CLOUDS. Clear, 0 Overcast, 10. 7 a. m.	2 p. m.	9 p. m.	RAIN AND SNOW. Depth of Rain and Snow in Inches. Time of Begining.	Time of Ending.	Duration. h. m.	Amount of water	OZONE. 0 10
Sunday, 31.	n. e.	e.	s. s. e.	132	1½	4.00 am	.596	.635	.658	100	90	90	10	9 cu.	10	1.30 pm	4 pm.	2.30	.03	0
Monday, 1.	w. s. w.	s.	s.	119	2	4.00 pm	.644	.717	.706	85	70	90	10	2 cir. cu. s	3 cu.	-----	-----	-----	--	0
Tuesday, 2.	s. s. e.	s.	s.	118	2½	3.30 pm	.706	.717	.693	90	70	85	10	3 cir. cu.	8 cu.	-----	-----	-----	--	0
Wednesday, 3.	n. w.	n. n. e.	s. w.	61	¼	2.00 pm	.648	.663	.744	95	57	77	3 cir. cu.	1 cir.	0	-----	-----	-----	--	0
Thursday, 4.	n. n. w.	n. w.	s. s. w.	57	¾	5.00 pm	.641	.765	.816	76	56	74	0	3 cir. cu.	0	-----	-----	-----	--	1
Friday, 5.	w. n. w.	s. s. e.	s. w.	82	¾	3.40 pm	.757	.855	.787	82	62	74	2 cir.	0	0	9.15 pm	10 am.	0.45	.07	0
Saturday, 6.	s. s. w.	s. s. w.	s. w.	176	5¼	2.20 pm	.772	.874	.814	78	60	82	2 cir. cu.	1 c. s.	6 cu.	-----	-----	-----	--	3

Distance traveled during the week .... 745 miles.
Maximum force .... 5¼ lbs.

Total amount of water for the week .... .10 inch.

DANIEL DRAPER, Ph. D.

Director Meteorological Observatory of the Department of Public Parks, New York.